THE
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WATER QUALITY EVALUATION

of

APSEY LAKE

1970

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by

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SUMMARY

Limnological and biological data for Apsey Lake, source of water supply for the town of Espanola were collected over a six day period in August and September, 1970. Results demonstrated that chemical characteristics are generally suitable for water supply purposes, however, the lake was shown to be mesotrophic in nature and was characterized (as on previous occasions) by troublesome levels of algae. Although reduced numbers of algae were present in deeper waters during the survey, an extended sampling programme would be necessary to demonstrate that a deeper intake would solve existing problems.

Poor water quality will be experienced on a periodic basis unless treatment facilities for algal removal and taste and odour control are added to the existing system. The possibility of locating an alternative source of supply might also be considered.

INTRODUCTION

Complaints of objectionable tastes and odours in the municipal water supply system at Espanola were first reported during July 1963. These conditions persisted periodically until October of the same year. Severe odours again developed in May 1964 and personnel of the Ontario Water Resources Commission carried out an investigation to ascertain the causes and to assess practical methods of control. Results of the study indicated that the malodourous nature of the water was dependent on the types and abundance of algae present in the raw water supply. Increasing the chlorine demand to 1.0 mg/1 seemed to improve the palatability of the water. The report recommended that, "Follow-up tests should be conducted with chlorine dioxide treatment, preferably on a plant-scale basis" and "...threshold odour tests be conducted concurrently with the application of chlorine dioxide." Additionally, the report suggested that "... copper sulphate should be applied by or under the supervision of the Biology Branch of the Ontario Water Resources Commission..." to alleviate tastes and odours owing to troublesome levels of algae.

Since this report, personnel of the Biology Branch have received a number of complaints of tastes and odours developing in the municipal supply system; the complaints were usually associated with periods in ice break-up or spring run-off conditions.

On August 29 and 31 and September 3, 1970 staff of the Technical Advisory Services Branch of the Division of Research carried out a preliminary study to determine whether more suitable water quality existed at an alternative deep-water intake location in Apsey Lake. Biological and limnological conditions were evaluated by personnel of the Biology Branch, Division of Laboratories.

METHODS

Field methods

Biological and chemical samplings and physical measurements were carried out on three dates (August 29 and 31 and September 3, 1970) in Apsey Lake by staff of the Technical Advisory Services Branch of the Division of Research. The field work was completed at Station A, the present intake location and at Station B,an alternate deep-water intake site (Figure 1). Depths of the two locations are 36 and 61 feet, respectively. At Station B samples were collected from 0.5 10, 25, 40 and 55 feet; for comparative purposes samples were obtained from the present intake depth of 27 feet at Station A.

Measurements of pH, turbidity (in Jackson Turbidity Units), colour (in Hazen Units), iron (as Fe), total hardness (as $CaCO_3$), alkalinity (as $CaCO_3$), dissolved oxygen and free carbon dioxide were completed on each sample using a portable Hach kit.

Samples obtained for identification and enumeration of algae were preserved with Lugol's iodine at the time of sampling. These samples as well as those collected for nutrient determinations, were returned to the OWRC laboratory in Toronto for analyses.

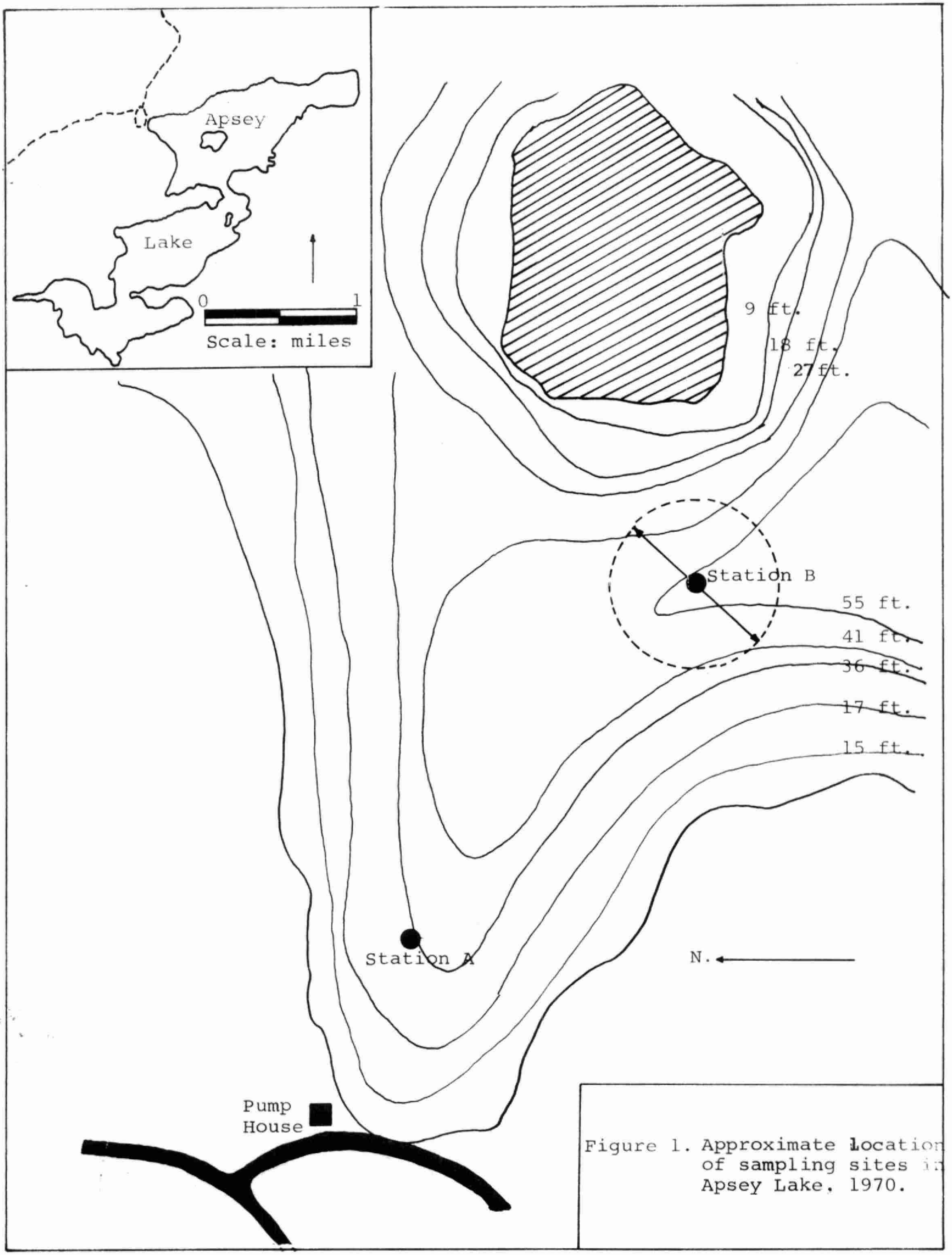

Figure 1. Approximate location of sampling sites in Apsey Lake, 1970.

Laboratory methods

Nutrient analyses were performed on each sample for nitrogen (total Kjeldahl and free ammonia nitrogen as N) and total and soluble phosphorus (as P).

The algal samples were concentrated by allowing the cells to settle for 72-96 hours, and the overlying liquid was then syphoned or decanted. Subsequently, the cells were re-suspended in a 25-ml concentrate and a 1-ml aliquot was transferred into a Sedgwick-Rafter counting cell. Most of the algal forms were identified to genus at a magnification of 220X. Where accurate identifications were impossible, wet mounts were prepared and examined at higher magnifications. Quantitative results were expressed as areal standard units per millilitre. One areal standard unit is equal to an area of 400 square microns (Whipple 1914). Depending on the density of the concentrate, strips or fields were counted. Between 250 and 600 organisms per aliquot were identified and measured.

RESULTS

Physical characteristics

Colour readings were less than 5 units at all depths at Station B whereas a value of 15 units was recorded on each sampling date at Station A.

Turbidities expressed in Jackson Turbidity Units are summarized in the following table.

Depth	Station A Max.	Min.	Mean	Depth	Station B Max.	Min.	Mean
27 feet	7.6	7.2	7.4	0.5 feet	1.1	1.0	1.0
				10.0 feet	1.9	1.5	1.7
				25.0 feet	3.0	2.8	2.9
				40.0 feet	3.9	3.8	3.8
				55.0 feet	2.6	2.6	2.6

As indicates, turbidities were higher at Station A than at Station B. At the latter location a trend towards increasing turbidity with depth to 40 feet was apparent.

Notwithstanding some limitations in terms of the frequency of temperature measurements with depth, a thermocline or zone of rapid temperature change was detected on the three sampling dates at Station B by a decrease in water temperature of 9°C between 15 and 35 feet. (Figure 2). Similar temperatures were recorded at Station A (27 feet) and Station B (25 feet). It is likely therefore, that the present intake is located in the mid-thermocline stratum of water.

Chemical and biological characteristics

Moyle (1949) considered a total alkalinity of 40 mg/l to be a natural separation point between hard and soft waters. Station A and B of Apsey Lake were characterized by an alkalinity of 28 mg/l. Total hardness at both locations was 28 mg/l.

A striking maximum in oxygen concentrations was apparent in the mid-portion of the thermocline at Station B (Figure 2). This type of oxygen distribution is termed positive heterograde. Dissolved oxygen levels at the 27 foot depth of Station A were supersaturated with respect to surface concentrations (as detected at Station B).

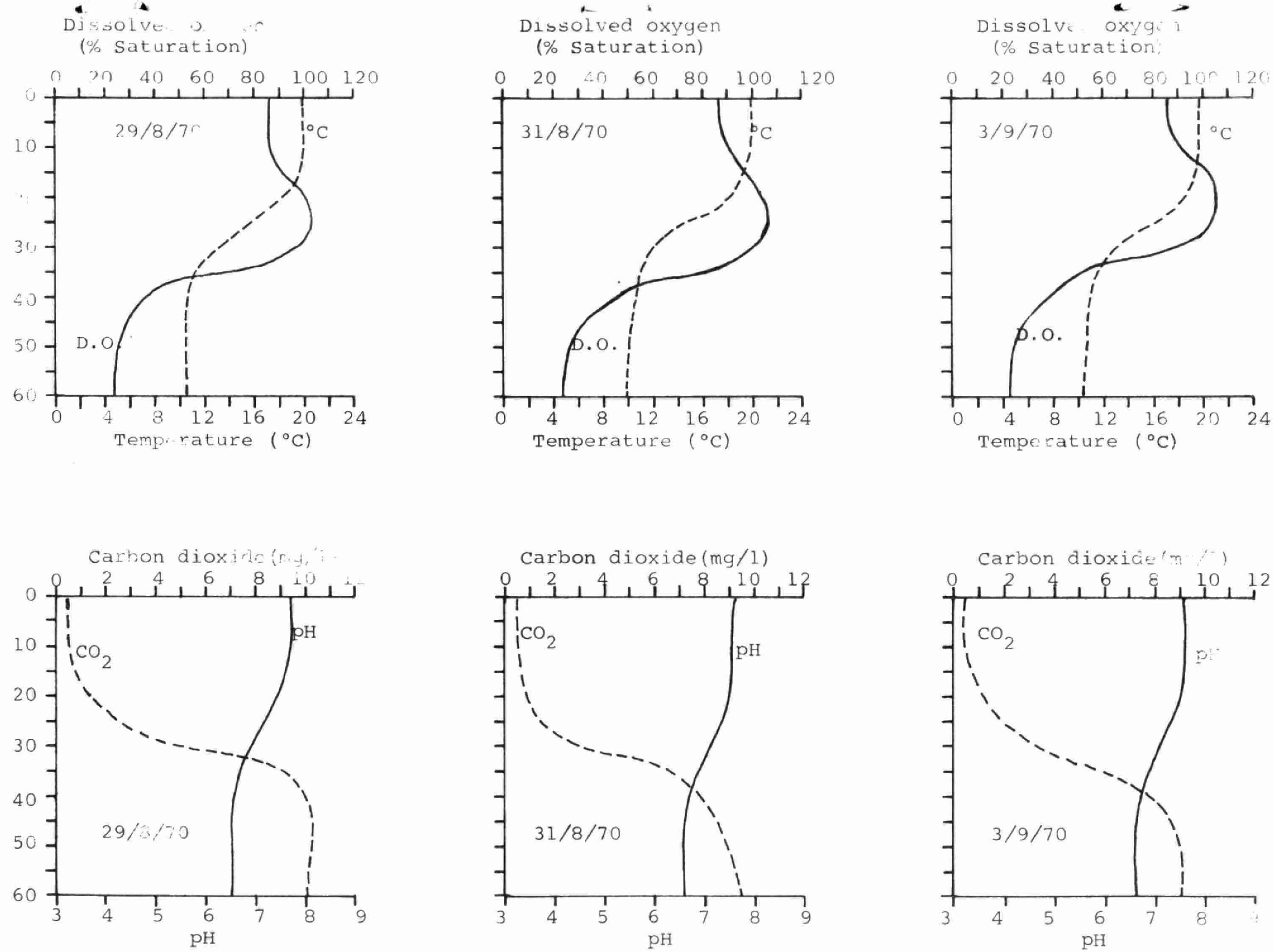

Figure 2. Profiles of dissolved oxygen, temperature, carbon dioxide and pH on three days in 1970 at Station B in Apsey Lake. Shaded areas approxima · the position of the thermocline.

The pH at Station B was higher at the surface than in the deeper strata (Figure 2).

Free carbon dioxide concentrations were 7-8 times higher in the hypolimnion (zone of colder water below the stable thermocline) than in the warmer epilimnetic (above thermocline) waters (Figure 2).

Concentrations of total phosphorus in the hypolimnion were considerably higher than those recorded from the epilimnion (Figure 3). Soluble phosphorus levels were highest in the near sediment waters, however, increases with depth were not as striking as those detected for the total phosphorus fraction. It is of interest that total phosphorus concentrations at 55 feet at Station B increased from 0.011 mg/l on August 29 to 0.036 mg/l on August 31 to 0.060 mg/l on September 3 (Figure 3). It is significant to note that iron concentrations were not detected at Station B. Total phosphorus levels were higher at Station A than at an approximately similar depth for Station B.

Nitrogen as free ammonia and total Kjeldahl were characterized by a mid-thermocline maximum (Figure 3). Generally, levels of both nitrogen fractions were higher in the near-sediment strata than in surface waters; additionally, the deep-water concentrations increased considerably between August 29 and September 3.

Figure 4 depicts the vertical distribution of standing stocks of phytoplankton at Station A and B in Apsey Lake on August 29 and 31 and September 3. Near-surface maximum levels were not apparent at Station B; highest numbers were present in the mid-thermocline strata on the three sampling dates. The most important algae present were the blue-greens <u>Oscillatoria</u>, <u>Aphanizomenon</u> and <u>Anabaena</u>.

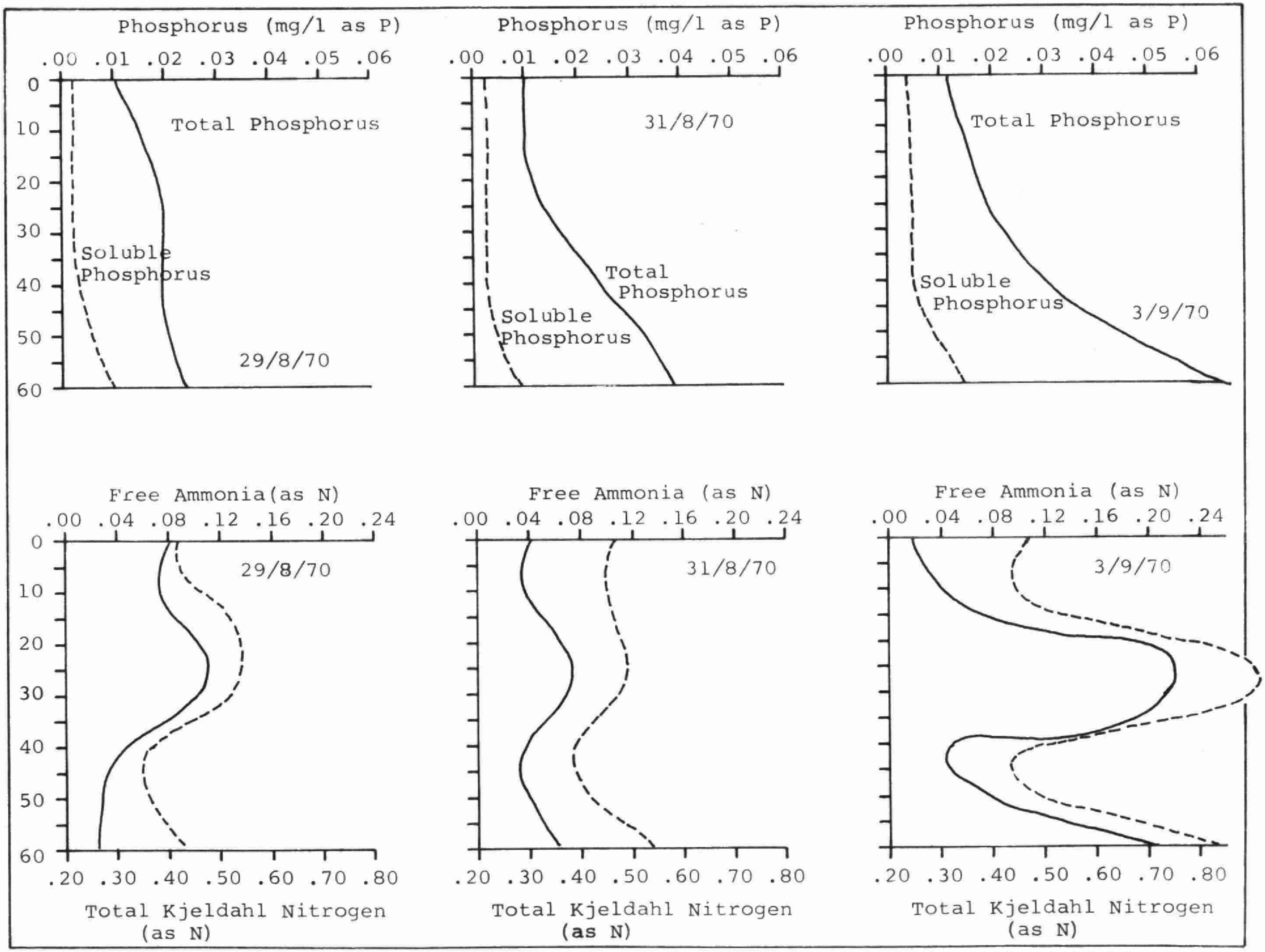

Figure 3. Profiles of total and soluble phosphorus, free ammonia and total Kjeldahl nitrogen on three dates in 1970 at Station B in Apsey Lake. Shaded areas approximate the position of the thermocline.

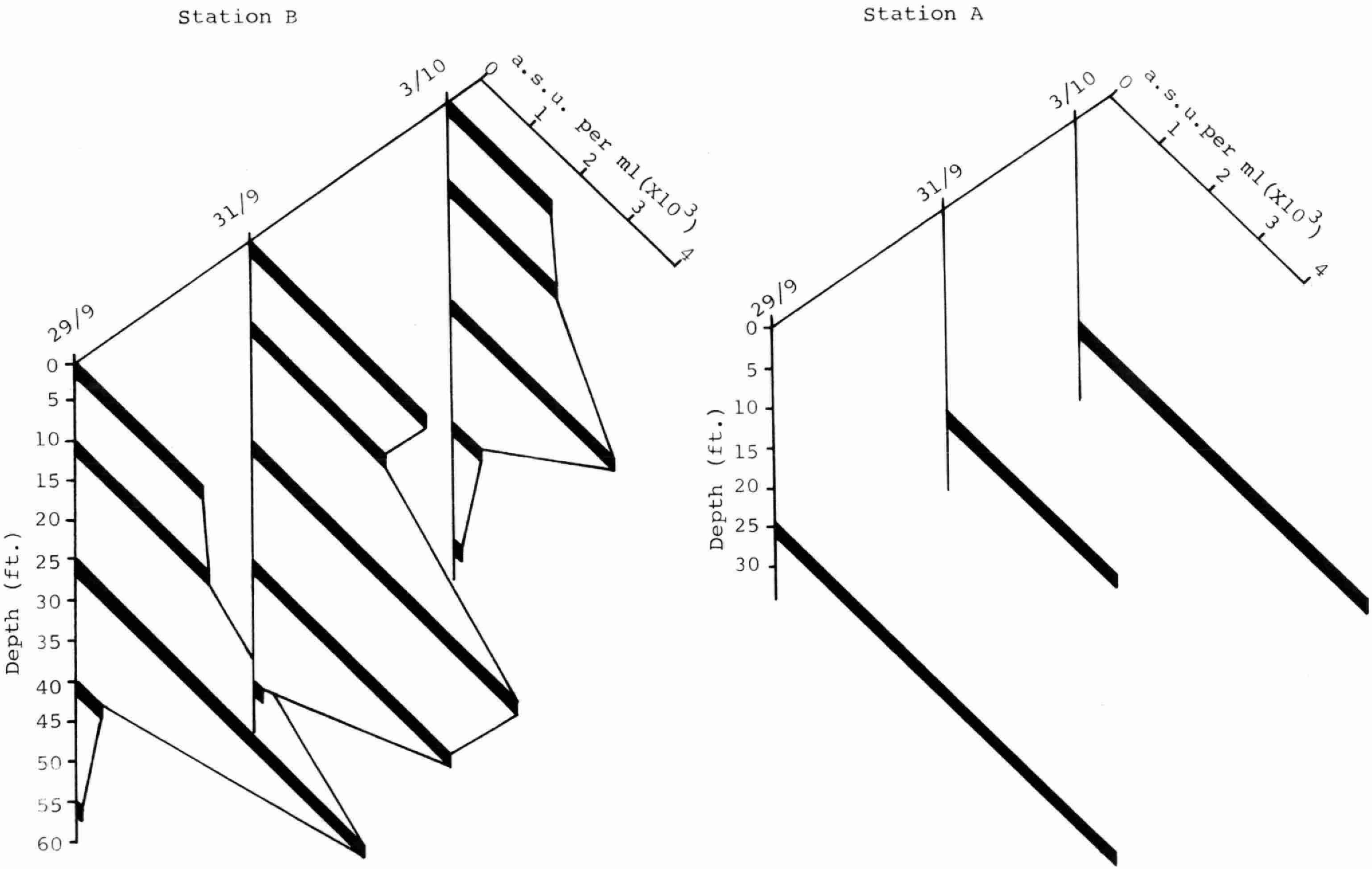

Figure 4. Standing stocks of total phytoplankton at Stations A and B, Apsey Lake, on three days, 1970. All results are expressed in areal standard units per millilitre.

The mid-depth samples at both sampling sites were dominated almost exclusively by Oscillatoria. Highest total a.s.u. values were 7,001 (27 feet) for Station A and 6,060 (25 feet) for Station B on August 29. Areal standard unit values for Oscillatoria for these samples was 6,948 and 4,695, respectively.

DISCUSSION

Status of enrichment in Apsey Lake

Depending upon the degree of plant nutrient enrichment and resulting biological productivity, lakes of north temperate regions as well as many tropical lakes have been classified into three intergrading types: oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes are poorly supplied with plant nutrients and support little plant growth. As a result, these lakes are generally deep, clear and unproductive with the deeper waters well supplied with oxygen throughout the year. Such lakes support cold-water species of fish such as trout, whitefish and herring. Eutrophic lakes on the other hand are richly supplied with plant nutrients and support heavy plant growths. These lakes are turbid, warm, productive and contain warm-water game fish species such as walleye, pike, perch and other less valued species, for example, catfish and carp. The deeper waters become depleted in oxygen in the summer owing to decomposition of the abundant organic material produced. Lakes of intermediate types are termed mesotrophic; that is, they have a moderate supply of nutrients, plant growths and biological production.

The positive heterograde oxygen distribution or metalimnetic maximum in Apsey Lake resulted from optimum photosynthesis in the lower portion of the thermocline. This particular type of distribution in late summer is similar to that reported from a number of small mesotrophic lakes in

Indiana (Eberly 1959, 1963, 1964; Wetzel 1966), Austria (Findenegg 1963, 1964), Minnesota (Baker et al. 1969) and Ontario (Michalski and Robinson 1969). Based on oxygen considerations, it is logical to assume that Apsey Lake is characteristically mesotrophic.

The higher pH values in the surface waters (when compared with those in the hypolimnion) resulted from the reduction of free CO_2 and calcium bicarbonate during photosynthesis. The decrease in pH in hypolimnetic waters was related to conditions of decomposition with corresponding CO_2 and calcium bicarbonate increases.

The vertical distribution of phosphorus during thermal stratification is quite different in nutrient-poor and productive lakes. In the former type of lake, relatively little variation exists with depth in total phosphorus. In contrast, the hypolimnetic waters of productive lakes such as Apsey Lake are characterized by increases in total and soluble phosphorus. It is likely that settling of phytoplankton from the mid-thermocline depths was instrumental in effecting the exceptional increases of the total phosphorus fraction in the lower waters of the hypolimnion. Indeed, Steiner (1938) pointed out that the increases in total phosphorus concentrations in the hypolimnion of productive lakes can be attributed to sedimentation of plankton.

Increases of free ammonia and total Kjeldahl nitrogen in the thermocline and in the lower portion of the hypolimnion are characteristic of mesotrophic and eutrophic lakes. Such increases which are caused by the confinement of organic material in the thermocline and bacterial and/or reduction processes in the hypolimnion, were apparent in Apsey Lake.

The mesotrophic lakes of Eberly (1959, 1963, 1964), Wetzel (1966), Findenegg (1963, 1964) and Baker et al. (1969) were characterized by a maximum development of *Oscillatoria* spp. within the thermocline (metalimnion). As described earlier, the metalimnetic increase in standing stocks of phytoplankton and related dissolved oxygen increases stemmed almost exclusively from the abundance of *Oscillatoria*. Optimum development of this genus at 20-30 feet may be related to its preference or requirement for colder temperatures, higher nutrient concentrations, lower light intensities, or a combination of these factors.

Evaluation of Apsey Lake as a potential source of domestic supply

General

Water for domestic uses must be free from pathogenic organisms, chemical substances and microscopic organisms which would otherwise impair the quality of the water. Other considerations such as corrosiveness, tendency to form incrustaceans, excessive soap consumption and effects of local pollutional sources are important in evaluating the quality of water intended for domestic use.

Chemical considerations

The OWRC has established a Permissible Criteria of 75 units and a Desirable Criteria of <5 units as an objective for colour. Apsey Lake at Station A was within acceptable limits; the colour values at Station B proved of exceptional quality.

Turbidity values at both locations were of moderate levels. The increase in turbidity with depth at Station D can be related to a corresponding increase in phytoplankton stocks.

Water temperatures at the present intake location (15°C) and at the proposed site (11°C) were well below a Permissible Criteria of 29°C.

For any individual sample, the Permissible and Desirable Criteria for dissolved oxygen is $\geq$ 3 mg/l and near saturation, respectively. Dissolved oxygen in the hypolimnion at Station B ranged between 2.5 - 3.0 mg/l and was well below saturation. Free carbon dioxide in domestic water is of significance only in connection with corrosion and aggressiveness of water, for it appears to have no direct physiological effect.

Water having pH characteristics ranging between 6.5 and 8.5 is permissible provided other conditions are satisfactory. Surface pH values at Station B were within this range, but approximated the lower extreme of this spectrum in hypolimnetic waters.

It is difficult to establish judicious criteria for evaluating levels of inorganic phosphorus in surface waters owing to the rather complex role this element has in the aquatic ecosystem. It is generally agreed, however, that phosphorus is critical in stimulating plant and algal growths in the presence of other essential growth factors. Additionally, phosphates have been known to interfere with water coagulation processes through the formation of insoluble complex phosphate compounds, at concentrations as low as 0.01 mg/l (as P). It was obvious that sufficient concentrations of phosphorus were available in the euphotic zone of Apsey Lake to support the development of troublesome levels of algae.

The Permissible and Desirable Criteria for ammonia are 0.5 and <0.01 mg/l, respectively. Concentrations of

the free ammonia should be relatively low as this compound can react readily with chlorine to form chloramines which have markedly less disinfecting efficiencies than the HOCl molecular or even OCl^- forms of free chlorine. Additionally, ammonia may promote the growth of algae and cause corrosion in a distribution system. As indicated in Figure 3 ammonia levels were never in excess of 0.25 mg/l as N.

Biological aspects of water supply

Excessive algal populations lead to clogging of filters and to the development of obnoxious tastes and odours in the water. In all instances problems stem from an over-abundance of algae, however, the numbers required to create difficulties will vary from species to species and from one specific problem to the other.

The problems of taste and odour in the Espanola municipal water supply system have been well documented. For example, in 1964 Schenk and Oda found that the flagellated alga *Synura* and *Dinobryon* were primarily responsible for the cause of taste and odour in the water supply during the month of May.

The presence of exceptionally high numbers of *Oscillatoria* in the metalimnion or thermocline of Apsey Lake during late August and early September, 1970 would undoubtedly affect the palatability of the municipal water supply, especially in light of the fact that water for domestic use is currently drawn from the mid-thermocline stratum. The past problems as well as the mesotrophic conditions indicated by the present survey demonstrated that periodic algal problems will occur.

It must be appreciated that it is virtually impossible to make definite conclusions on the suitability of a potential water supply based on results of a short-term sampling programme. Although, on the basis of this survey, hypolimnetic water would be an improvement over mid-thermocline water, careful appraisal based on extended sampling would be necessary to demonstrate the validity of a change in intake location. Considering the current mesotrophic nature of the lake, it is unlikely that this course of action would produce consistently superior water. Poor water quality will be experienced on a periodic basis unless treatment facilities for algal removal and taste and odour control are added to the existing system. The possibility of locating an alternative source of supply might also be considered.

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REFERENCES

BAKER, A. L., A. J. BROOK and A. E. KLEMER. 1969. Some photosynthetic characteristics of a naturally occurring population of Oscillatoria Agardhii Gomont. Limnol. and Oceanogr., 14: 327-333.

EBERLY, W. R. 1959. The metalimnetic oxygen maximum in Myer's Lake. Invest. Indiana Lakes and Streams, 5 (1): 1-46.

______________. 1963. Oxygen production in some northern Indiana lakes. Proc. Ind. Waste Conf., Purdue Univ., 17: 733-747.

______________. 1964. Primary production in the metalimnion of McLish Lake (northern Indiana), an extreme plus heterograde lake. Verhandl. Intern. Ver. Limnol., 15: 394-401.

FINDENEGG, I. 1963. Gewässegüte und Seenschutz. Oesterr. Wasserwirtsch., 15: 65-70.

______________. 1964. Types of planktic primary production in the lakes of the Eastern Alps as found by the radioactive carbon method. Verhandl. Intern. Ver. Limnol. 15: 352-359.

MICHALSKI, M. F. P., and G. W. ROBINSON. 1969. Status of Enrichment of Silver Lake. OWRC Report. 1-18 p.

MOYLE, J. B. 1949. Some indices of lake productivity. Trans. Am. Fish. Soc., 76: 322-334.

SCHENK, C. F. and A. ODA. 1964. Taste and Odour Problems in Espanola Water Supply. OWRC Report. 1-28 p.

STEINER, M. 1938. Zur Kenntnis des Phosphatkreis-laufes in Seen. Naturwissenschaften. 26.

WETZEL, R. G. 1966. Variations in productivity of Goose and hypereutrophic Sylvan Lakes, Indiana. Invest. Indiana Lakes Streams 7(5): 147-184.

WHIPPLE, G. C. 1914. The microscopy of drinking water. John Wiley and Sons, New York. 3rd ed., 409 p., 19 plates.

APPENDIX A

Algae counts completed on samples collected from pilot plant studies on Apsey Lake water during August and September, 1970. All results are expressed as areal standard units per millilitre.

Sample Location	Blue-greens	Flagellates	Greens	Diatoms	Total
Chlorination and Ozonation and DE filtration	0	0	4	0	4
Ozonation only	4,866	45	16	17	4,944
Clarifier-Bottom-alum and soda	2,830	71	15	31	2,947
Clarifier-Top-alum and soda	2,159	27	7	8	2,201
Clarifier-Alum and soda and carbon filter	322	22	0	0	344
Superchlorination and carbon filter	717	0	8	11	736
Superchlorination and top of clarifier	1,785	219	12	4	1,785
Superchlorination, soda and DE and carbon filter	79	0	2	2	83
Clarifier-chlorination, soda, alum coag. aid, and DE filter	3	4	0	0	7
Ozonation and carbon filtration	1,473	47	30	0	1,550